BEDROCK GEOLOGY OF THE CLEVELAND SOUTH QUADRANGLE, CLEVELAND, OHIO

A Thesis

Presented in Partial Fulfillment of the

Requirements for the Degree Bachelor of Science

by

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1981

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Acknowledgements

I would like to thank Dr. George E. Moore Jr. for the suggestion of the thesis topic and for his valuable assistance in writing it. I would also like to thank Mike Hansen of the Ohio Geological Survey for his help in deciding which 7½ minute quadrangle to map and for his identification of the paleoniscid imprint found in the Euclid Siltstone.

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Abstract

The bedrock in the vicinity of Cleveland, Ohio consists of flat-lying Upper Devonian and Mississippian shale, siltstone, and sandstone. It is the purpose of this thesis to provide a detailed bedrock geologic map of the Cleveland South 7½ minute quadrangle and to include a description of the structure and facies relationships observed in the strata exposed in the map area. Although the bedrock is covered by Quaternary glacial material in most places, only the thickest deposits, in the Cuyohoga Valley area, were shown on the map. These deposits fill a rather deep preglacial valley. Other glacial deposits in the area, such as ground moraines, glacial lake deposits, and glacial lake beaches, are either covered or obscured by extensive urbanization.

Field work was done from January through November, 1981 and included observation of formational contacts, measurement of stratigraphic sections, and collection of specimens for petrographic studies. Water-well logs on record at the Division of Water, Ohio Depatment of Natural Resources, were consulted to obtain contact elevations where exposures were not found.

Geography of the Map Area

The general form of the land surface of the area is that of a series of four bedrock terraces, striking east-west. These terraces descend in elevation from 1150 feet above sea level in the south to 571 feet above sea level along the shore of Lake Erie. The southernmost and highest terrace is composed of Sharpsville Sandstone, which is more resistant than the overlying Meadville Shale and Underlying Orangeville Shale. The average elevation of this terrace is approximately 1050 to 1100 feet. The next terrace is composed of the Berea Sandstone, which lies between the Orangville Shale above and the Bedford Shale below. Its elevation averages 850 to 880 feet. To the north are two, less prominent, terraces of Cleveland Shale and Chagrin Shale at elevations of 750 feet and 710feet respectively.

These terraces are cut by the Cuyohoga River and its tributaries, Big Creek and Skinners Run. The entire area drains northward into Lake Erie via the Cuyohoga River.

The Cuyohoga River Valley is cut into glacial deposits that fill a preglacial valley whose course is nearly parallel to the present valley. The Cuyohoga valley is 2000 to 6300 feet wide, with valley walls as much as 150 feet high. These valley walls consist of glacial material except along the east wall in Garfield Heights, where a 120-foot bedrock cliff is exposed.

Big Creek enters the map area in the northwest quarter and flows eastward to join the Cuyohoga River. Its valley is 800 to 2000 feet wide and 80 to 120 feet deep. Cliffs along the valley walls expose the upper Chagrin Shale and lower Cleveland Shale. The stream formerly meandered widely but has been channeled and the valley filled, to a great extent, with interstae 71.

Skinners Run enters the map area from the south, in Parma, flows northward for two miles, and then turns eastward to join the Cuyohoga River in the suburb of Independence. Its valley is wide where the stream erodes into shale and narrow where it encounters the more resistant Berea Sandstone. The stream exposes a nearly complete section of the bedrock discussed in this paper. The exposures along this stream were first studied and described by Prosser(1912).

Another prominent surface feature is a low ridge striking east-west across the central part of the area, west of the Cuyohoga River. It is 20 to 40 feet high and 0.75 miles wide. H.P. Cushing (9131) described as a terminal moraine and named it the Cleveland Moraine.

The area as a whole is extensively urbanized as most of it lies within the city limits of Cleveland or within nearby suburbs. The only undeveloped areas exist in the valleys of the tributary streams.

Geology

The formations considered in this study include the Upper Devonian Ohio Shale, and the Mississippian Bedford Shale, Berea Sandstone, Orangeville Shale, Sharpsville Sandstone, and Meadville Shale. The Ohio Shale is divided into the Chagrin and Cleveland members, and the Bedford Shale includes the Euclid siltstone member. The boundary between the Devonian and Mississippian has long been controversial, but in this study was placed between the Cleveland Shale and Bedford Shale, in accordance with the most recent study of these formations (Pepper, Demarest, and DeWitt, 1954). Below the Ohio Shale are Cambrian, Ordovician, and Silurian carbonate and evaporite deposits. Below these are Precambrian crystalline rocks. None of the rocks below the Ohio Shale are exposed in the map area.

H.P. Cushing (1931) recognized the Olmsted member of the Cleveland Shale, since it resembled both the Cleveland and the Chagrin. This writer did not distinguish the Olmsted member but, rather, classified everything above the black marcasite bed at the bottom of the Cleveland as Cleveland Shale. Above this bed in most places is 12 feet of black shale overlain by 4 to 5 feet of blue-gray shale. This most likely represents intertounging of the Cleveland and Chagrin and for simplicity was considered to be Cleveland Shale.

Chagrin Shale

The lowest in elevation and therefore the oldest bedrock exposed in the map area is the upper portion of the Chagrin Shale member of the Devonian Ohio Shale. It was originally called the Erie Shale by Newberry (1870), but was renamed the Chagrin Shale by Prosser (1912) for its exposures in cliffs along the Chagrin River.

The Chagrin is a soft light blue-gray argillaceous shale with fine white mica flakes, and contains thin very continuous beds of bl e-gray siltstone 0.5 to 4 inches thick. The shale weathers pale red-brown and the siltstone weathers dark red-brown. Althogh no fossils were observed in the map area, abundant brachiopods and corals were found in Tinkers Creek, southeast of the map area. Disc-shaped calcareous concretions stained red-brown with iron oxides were observed at both Tinkers Creek and in the map area. Oscillation ripple marks, abundant prod and flute marks, and some burrow structures (see Fig. 1) are present in a cliff-exposure at Edgewater Park and in places along Skinners Run.

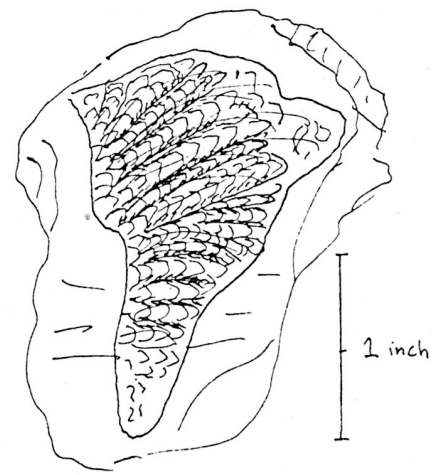

Figure 1 Burrow structure found in upper Chagrin Shale outcrop at Edgewater Park, Cleveland.

The Chagrin Shale is considered to be a wedge of carbon-free shale (see Table 1) thining to the west, separating the carbonaceous Huron Shale below from the Cleveland Shale above. The Chagrin increases in thickness eastward and is about 1200 feet thick in eastern Ohio and northwestern Pennsylvania where it grades into a massive fossiliferous siltstone (Cushing, Leverett, Van Horn, 1931, p35.). It is corelative with the Riceville Shale of White in northwestern Pennsylvania (Pepper, Demarest, DeWitt 1954, p 17).

Table 1. Analyses of the Chagrin Shale made for a local brick company by F.S. Peck and reported by Cushing(1931, p.106)

	1	2	3	4
Silica (SiO_2)	58.71	56.40	61.20	61.90
Alumina(Al_2O_3)	21.90	23.02	19.21	21.55
Iron Oxide(Fe_2O_3)	4.55	4.50	4.55	4.25
Magnesia(MgO)	2.00	1.64	1.46	1.44
Lime(CaO)	1.67	.85	2.00	1.50
Combined Water(H_2O)	6.64	5.91	9.13	4.96
Sulphur Trioxide(SO_3)	2.57	.86	.43	.20
Carbon(C)	.00	.00	.00	.00

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The contact between the Chagrin and the overlying Cleveland Shale dips westward in the map area. This anomalous dip can be explained by the general wedged shape of the Chagrin unit as it thins westward. The contact is well defined and exhibits no erosional channels or scour surfaces which would indicate prolonged uplift of the Chagrin after deposition. However, the uppermost Chagrin is very soft, somewhat disintegrated, and yellow in color just below the basal black marcasite bed of the

Cleveland Shale. Cushing considered this to be an unconformity and placed the Devonian-Mississippian boundary here. The writer considers this to represent a small hiatus preceding the transgression of the sea in which the Cleveland was deposited.

Also, near the contact are numerous anticlines with an amplitude of approximately 7.5 to 9 feet and 23 to 31 feet long. These small folds include both formations in some instances. Judging by the nature of the bedding around these folds it is thought they they formed after the deposition of both formations.

Cleveland Shale

The Cleveland Shale member of the Ohio Shale lies directly above the Chagrin Shale. It is typically a slaty carbonaceous jet-black shale and silty shale whose basal portion contains a bed of black marcasite and blue-gray and black shale beds which grade vertically into homogenous black shale and eventually into black silty shale. It weathers dark gray-brown and purple. Pyrite nodules are fairly abundant as are fossil fish and plant fragments. No current structures were found in the Cleveland.

The black marcasite bed can be best observed in an exposure in Skinners Run at an elevation of approximately 700 feet, just below a small falls. It is 6 to 7 inches thick in this locality. Weathered portions are very friable and where the exposure is recent it is extremely hard and heavy. In thin section the marcasite occurs as subrounded to subangular fine- to medium- size grains with concentric rings in cross section, around plant or bone fragments. The marcasite grains comprise 60 to 70 percent

of the rock and in exist in a matrix of carbonaceous matter that dissolved easily when samples were cut on the water-saw.

From the above observations the environment of deposition is interperated as a deep low-energy one with poor circulation, and thus lacking in oxygen. Abundance of decaying organic matter resulted in a reducing environment as evidenced by the existence of plant fragments and the black color of the rock.

The section of Cleveland Shale exposed in the map area is 42 to 47 feet thick. It increases in thickness to the west where it overlies the Huron Shale and thins to the east overlying the Chagrin. It also thins to the south where it lies unconformably on Ordovician limestone.

Bedford Shale

The boundary between the Devonian and Mississippian is placed between the Cleveland and the Bedford Shale. This boundary was chosen for lithologic reasons by Pepper, Demarest, and DeWitt(1954). The rocks of Bedford age and younger represent the beginning of deposition of coarser sediments. There is also some fossil evidence supporting this argument (Pepper, Demarest, and DeWitt; 1954, p.13).

The base of the Bedford in most outcrops in the map area contains the Euclid Siltstone member. This is a massive hard blue-gray siltstone wedge that thins westward. It is named for its exposure in a quarry east of Cleveland in Euclid, where it is known as the Euclid Bluestone. Good exposures exist in the cliff

in the east wall of the Cuyohoga Valley in Garfield Heights, in a stream along Stone Road in the town of Independence, in the far southeastern corner of the map area, and along Skinners Run. The blue-gray siltstones in Skinners Run were not considered to be Euclid Siltstone by Cushing (1931). This writer believes that although the massive thick beds of typical Euclid Siltstone do not exist here, the similarity in color, grain size, and the positionbetween Cleveland Shale and Bedford Shale suggest that they are a western extension of the Euclid. It occurs as lenses that have scoured into the surrounding black shale(Fig. 2).

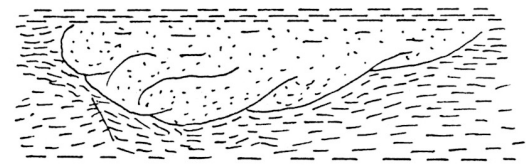


Figure 2. Lense of Euclid Siltstone exposed along Skinners Run.

Concentric rings of iron-oxide staining can be seen when a freshly broken surface is examined. It is in such a deposit directly under the Broadview Road bridge that an imprint of a paleoniscid, an armoured fish, as identified by Mike Hansen of the Ohio Geological Suvey, was found by the writer. Euhedral medium-size pyrite grains also occur in these deposits. Judging by the scour surface and the contrast in grain size with the surrounding rock, these deposits are interpereted as rapidly deposited turbidites.

Further upstream there is blue siltstone with flow rolls, flute casts, prod marks, and oscillation ripple marks. This grades upward into blue-gray silty shale and eventually into the soft red to purple shale characteristic of the Bedford Shale.

This red shale is traceable southward from the map area into West Virginia and Kentucky (Pepper, Demarest, and DeWitt; 1954, p. 26). It is considered to have been deposited subaerially as a delta striking north-south across Ohio and is much longer than it is wide. Channel sands eoded into the upper Bedford can be traced as long sinuous channels extending down the length of the red Bedford delta. Whether it was deposited above or below sea level is difficult to determine. The existence of oscillation ripple marks in the red Bedford in a tributary of Big Creek near the intersection of Pearl and Snow roads, suggest below sea level deposition. What can be said with certainty is that the environment of deposition of the red Bedford was a low energy one in which oxygen content fluctuated to produce alternating reducing and oxidizing conditions.

Berea Sandstone

The Berea Sandstone was named by Newberry(1870) for its exposures in quarries near the city of Berea. Its thickness in the map area varies from 40 to 80 feet. This great variation is due to its basal channel character. The channels it has filled into the underlying Bedford are as much as 23 feet deep locally. The Berea Sandstone can be divide into three sections: a lower massive thick bedded channel sand, a middle cross-bedded fluvial sand, and a thin-bedded oscillation ripple maked marine sand. A basal bed of black and white medium- to coarse-grained marcasitic sandstone was observed in a stream near Pearl and Snow roads and also in Skinners Run below the Snow road bridge. The lower

massive portion is generally buff to orange in color but in some places consisted of white quartz grains with occasional reddish-purple grains. There is no cross-bedding or flow structures and no fossils were found. This section is 8 to 23 feet thick. This massive channel sand grades upward into a light brown and orange-brown trough cross-bedde sandstone 8 to 10 feet thick. This then grades upward into the upper section which is characterized by low-angle crossbedding and generally thin-bedded character, light gray to orange-brown in color.

The Berea Sandstone in thin section generally cosists of subangular to subrounded quartz grains cemented by hematite and calcite. The samples averaged to be 70 to 80 pecent quartz, 5 to 35 percent hematite, and 5 to 15 percent calcite. Muscovite and biotite are present in minor amounts. Chlorite was present in some samples giving the rock a mottled green color.

Much evidence exists which suggests a scour-and-fill origin of the lower channel sands as opposed to an offshore bar type of origin. This includes the sinuous shape of the channels, the presence of of pebbles of underlying shales, indicating a lithified state of these shales during their erosion, and lack of deformation of the shales which might have occured were the sands deposited as an offshore bar.

The middle portion is thought to have been deposited in a fluvial environment judging by the high angle trough cross beds. (see Fig.3, pl.3)

The upper portion contains continuous uniform oscillation ripple marks suggesting a shallow low energy marine environment (Pepper, Demarest, and DeWitt; 1954, p. 79-88).

Thus the entire sequence can be explained by regression of the sea and subsequent erosion in late Bedford time, followed by deposition of channel sands and cross-bedded sands in early and middle Berea time, and the reinvasion of the sea in late Berea time. The Berea Sandstone is overlain by black shale directly above indicating the continuation of this transgressive episode.

The Cuyohoga Group: Orangeville Shale, Sharpsville Sandstone, and Meadville Shale

The bedrock above the Berea Sandstone in the map area was first named by Newberry(1870) as the Cuyohoga Shale of the Waverly group in an attempt to relate them to similar rocks in southern Ohio. Studies by Cushing, Leverett, and Van Horn (1931) and by Pepper, Demarest, and DeWitt (1954) used the names designated by White (1880) for corelative formations in northern Ohio and western Pennsylvania.

Directly above the Berea Sandstone lies the Orangeville Shale (Fig.4, pl.3) It is a soft blue-gray to gray-brown homogeneous shale. The Sunbury Shale, a dark black shale, and the Aurora Sandstone are recognized as members of the Orangeville in some areas of Ohio but were not present in the outcrops observed. The Orangeville Shale is well exposed along Skinners Run and a few other smaller streams nearby whose headwaters cut into the terrace of the Cuyohoga Group. A broad valley is cut into this terrace by Skinners Run. In the Orangeville observed in this valley no concretions or silty layers existed as might in most shales. The upper boundary of the Orangeville

is transitional into the overlying Sharpsville Sandstone and was placed where the first beds of gray-blue to gray-brown arenaceous shale and shaly sandstone appear. Exposures of this formation were limited as the formation is a thin one and exists only in the southernmost portion of the map area.

The Sharpsville is a hard fine- grained blue-gray to gray-blue sandstone interbedded with blue-gray shale. The sandstone contains white mica flakes and some fossil shells. The formation here is approximately 60 to 80 feet thick.

The uppermost and youngest formation in the map area is the Meadville Shale. It caps the uppermost bedrock terrace with a gentle slope from the highest point on the map at 1150+ feet in elevation to about 1050 feet and the boundary between it and the Sharpsville Sandstone. The Meadville is composed of alternating shale and sandstone. It is predominantly blue-gray to blue-black sandy shale not unlike the Chagrin and Cleveland Shale. Flattened iron carbonate concretions are abundant.

The observations made of the Cuyohoga group indicates a transgression following deposition of the Berea and a return to deeper water low energy marine environment similar to that which existed in the Upper Devonian during deposition of the Ohio Shale.

Fig. 3- Berea Sandstone exposure on Skinners Run near Snow Road bridge. Note lower massive channel sand grading into thin-bedded crossbedded sand stone. Purple gray below is the Bedford Shale. Cliff face approximately 42 feet high.

Fig 4 - Orangeville Shale exposure along Skinners run just south of Ridgewood Dr.

References

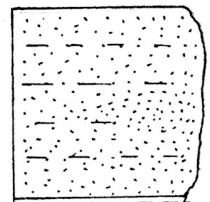
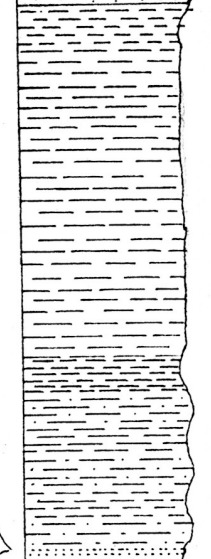
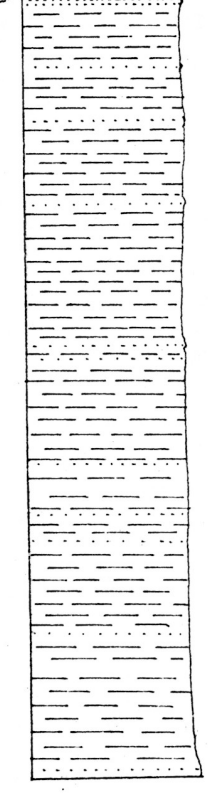
1 James F. Pepper, Wallace DeWitt Jr., and David F. Demarest, USGS Professional Paper 259, Geology of the Bedford Shale and Berea Sandstone in the Appalachian Basin (1954).

2 H.P. Cushing, Frank Leverett, and Frank R. Van Horn, USGS Bulletin 818 (1931).

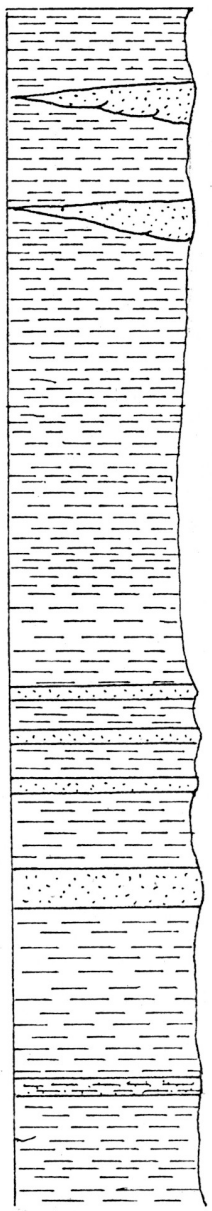
3 Charles S. Prosser, Geological Survey of Ohio, Fourth Series Bulletin 15, The Devonian and Mississippian Formations of Northeastern Ohio (1912).

4 Rodney M. Feldman. Alan H. Coogan, and Richard A. Heimlich, Field Guide to the Southern Great Lakes (1977).

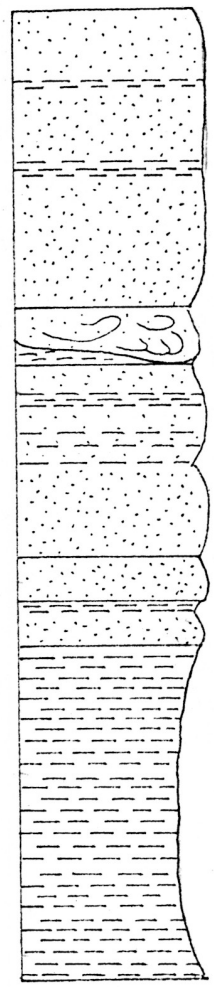
5 Aurele La Roque, Mildred fisher Marple, Ohio Geological Survey Bulletin 54, Ohio Fossils, tenth printing (1977).

Formation	Member	Lithology	Thickness (ft.)	Description
BEDFORD SHALE	Euclid Siltstone		14.5	Gray-brown sandy siltstone; weathers dark ed-brown and black; Thick bedding(5-6") and ball and pillow structures present.
OHIO SHALE	Cleveland Shale		5	Soft blue-gray argillaceous shale
			25	Jet-black shale; weathers dull red-brown and purple-gray in angular brown forms
			4	Soft blue-gray argillaceous shale
			12	Interbedded black shale and siltstone
			0.5	Black friable marcasite bed
	Chagrin Shale		61	Soft blue-gray argillaceous shale interbedded with thin(3-4") very continuous blue-gray siltstone beds

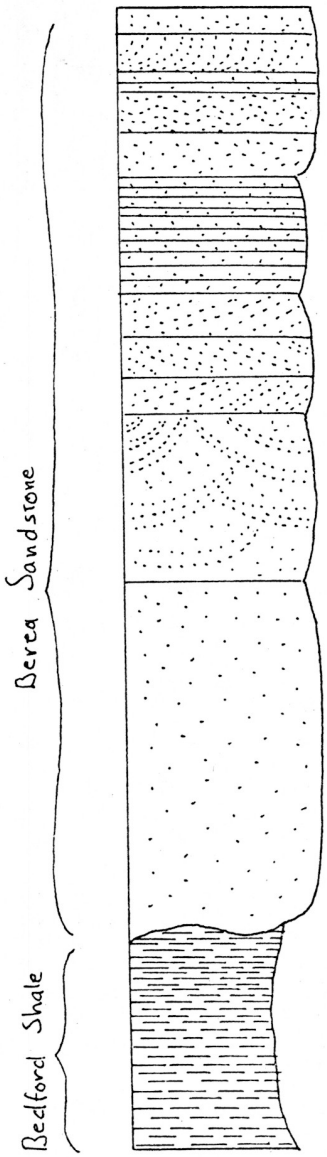
Section measured on Skinners Run
in Brooklyn Heights Park

Formation	Member	Lithology	Thickness (ft.)	Description
OHIO SHALE	Cleveland Shale			Black shale
			1.5-3	Massive blue-gray siltstone with flow rolls and flute casts
				Black shale
			1-2.5	
			7-10	Black shale, sometimes silty; weathers to dark purple and gary-brown
			0.4	Black shale interbedded with blue-gray siltstone
			0.4	
			0.4	
			0.75	Blue-gray siltstone
				Black shale
			0.3	Soft blue-gray clay
				Black shale; weathers to purple and dark gray-brown

Section measured on a stream near Stone Road in Brecksville

For-mation	Member	Lithology	Thick-ness (ft.)	Description
BEDFORD SHALE	Euclid Siltstone		8	Blue-gray massive siltstone interbedded with black shale
			1.5	Gray mudstone with flute casts and flow rolls
			3	Thick bedded blue-gray siltstone interbedded with black and blue-gray shale
			2.5	Massive blue-gray siltstone
			1	
			0.5	
OHIO SHALE	Cleveland Shale		7.5	Black silty shale; weathers gray and dark red-brown

Section measured on Skinners Run at Snow Road



Formation	Thickness (ft.)	Description
Berea Sandstone	8.5	Buff to tan medium-grained friable cross-bedded sandstone with oscillation ripple marks
	6	Orange, buff, and dark brown medium grained thin bedded sandstone
	6.5	Gray-brown to orange medium-grained thin bedded sandstone with low angle (10-15°) cross-bedding
	8-10	Light brown to buff medium-grained trough cross-bedded sandstone
	10-17	Massive medium-grained light brown channel sandstone containing some white quartz grains in reddish-purple matrix
Bedford Shale	11-14	Purple and gray soft argillaceous loosley compacted shale